

# USNO Analysis Center for Source Structure Report

*Alan L. Fey, David A. Boboltz, Roopesh Ojha, Ralph A. Gaume, Kerry A. Kingham*

## Abstract

This report summarizes the activities of the United States Naval Observatory Analysis Center for Source Structure for calendar year 2010. VLBA RDV experiments RDV75, RDV77, and RDV79 were calibrated and imaged. Images from these three experiments were added to the USNO Radio Reference Frame Image Database. VLBA high frequency (K/Q-band) experiment BL151b was calibrated and imaged. A Southern Hemisphere imaging and astrometry program for maintenance of the ICRF continued. Activities planned for the year 2011 include continued imaging of ICRF sources at standard and higher frequencies and continued analysis of source structure and its variation.

## 1. Analysis Center Operation

The Analysis Center for Source Structure is supported and operated by the United States Naval Observatory (USNO). The charter of the Analysis Center is to provide products directly related to the IVS determination of the “definition and maintenance of the celestial reference frame.” These include, primarily, radio frequency images of International Celestial Reference Frame (ICRF) sources, intrinsic structure models derived from the radio images, and an assessment of the astrometric quality of the ICRF sources based on their intrinsic structure.

The Web server for the Analysis Center is hosted by the USNO and can be accessed by pointing your browser to

[http://rorf.usno.navy.mil/ivs\\_saac/](http://rorf.usno.navy.mil/ivs_saac/)

The primary service of the Analysis Center is the Radio Reference Frame Image Database (RRFID), a Web accessible database of radio frequency images of ICRF sources. The RRFID contains 7,279 Very Long Baseline Array (VLBA) images (a 7.9% increase over the previous year) of 782 sources (a 10% increase over the previous year) at radio frequencies of 2.3 GHz and 8.4 GHz. Additionally, the RRFID contains 1,706 images (a 12% percent increase over the previous year) of 282 sources (a 0.7% increase over the previous year) at frequencies of 24 GHz and 43 GHz. The RRFID can be accessed from the Analysis Center Web page or directly at

<http://rorf.usno.navy.mil/rrfid.shtml>

The RRFID also contains 74 images of 69 Southern Hemisphere ICRF sources using the Australian Long Baseline Array (LBA) at a radio frequency of 8.4 GHz.

Images of ICRF sources can also be obtained from the Bordeaux VLBI Image Database (BVID) at

<http://www.obs.u-bordeaux1.fr/m2a/BVID/>

## 2. Current Activities

### 2.1. VLBA Imaging

Very Long Baseline Array (VLBA) observations for maintenance of the celestial and terrestrial reference frames have been carried out since about 1994. Since 1997, these VLBA RDV (Research and Development with VLBA) observations have been part of a joint program between the

USNO, the Goddard Space Flight Center (GSFC), and the National Radio Astronomy Observatory (NRAO). During each 24-hour VLBA RDV session, about 100 ICRF sources are observed at S/X-band (2.3/8.4 GHz) using the VLBA together with up to 10 additional geodetic antennas. Images are produced from these observations and made available through the RRFID.

VLBA experiment RDV77 (2009OCT07) was calibrated and imaged, adding 180 (90 S-band; 90 X-band) images to the RRFID including images of 21 sources (0110-361, 0332-403, 0521-403, 0627+814, 0705-412, 0714+457, 0717-393, 0855+143, 0857-329, 1015+057, 1149-084, 1232-338, 1327+504, 1406-297, 1456+044, 1817+157, 2005+372, 2039+037, 2215+150, 2311-373, 2348-432) not previously imaged.

VLBA experiment RDV75 (2009MAY13) was calibrated and imaged, adding 179 (90 S-band; 89 X-band) images to the RRFID including images of 27 sources (0007-325, 0114-211, 0115-214, 0227-369, 0347-211, 0422-380, 0422-389, 0436-129, 0843-336, 1027-186, 1255-177, 1302-208, 1339-287, 1346-306, 1550-242, 1613-350, 1622-310, 1647+744, 1749+701, 1751+288, 1759-396, 1906-217, 2000+472, 2120-309, 2122-238, 2307+106, 2357-318) not previously imaged.

VLBA experiment RDV73 (2009JAN21) was calibrated and imaged, adding 175 (87 S-band; 88 X-band) images to the RRFID including images of 23 sources (0035-252, 0043-268, 0055-059, 0420+022, 0502-152, 0515+208, 0529+483, 0532-378, 0632-235, 0741-444, 0847-120, 0915-118, 1059-438, 1133-032, 1243-160, 1428+370, 1602-115, 1633-409, 1650-157, 1711-209, 1913-272, 2157-255, 2220-318) not previously imaged.

Collaborations continue with Glenn Piner at Whittier College and Patrick Charlot of the Laboratoire d'Astrophysique de Bordeaux to calibrate and image several of the VLBA RDV experiments.

## 2.2. VLBA High Frequency Imaging

A program to extend the ICRF to 24 and 43 GHz continued in 2010. These observations are part of a joint program between the National Aeronautics and Space Administration, the USNO, the National Radio Astronomy Observatory (NRAO), and the Laboratoire d'Astrophysique de Bordeaux. During the calendar year 2010 two papers were published in the *Astronomical Journal*:, 1) "The Celestial Reference Frame at 24 and 43 GHz. I. Astrometry" by Lanyi et al. and 2) "The Celestial Reference Frame at 24 and 43 GHz. II. Imaging" by Charlot et al. (see § 5).

VLBA high frequency experiment BL151b (2008DEC18) was calibrated and imaged adding 187 (K-band only) images to the RRFID including two sources not previously imaged.

## 2.3. ICRF Maintenance in the Southern Hemisphere

The USNO and the Australia Telescope National Facility (ATNF) continue a collaborative program of VLBI research on Southern Hemisphere source imaging and astrometry using USNO, ATNF, and ATNF-accessible facilities. These observations are aimed specifically toward improvement of the ICRF in the Southern Hemisphere.

A program to monitor the structure of quasars south of declination  $-30^\circ$  that are either known to be gamma-ray loud or are expected to be gamma-ray loud continued. The program, called TANAMI (Tracking Active galactic Nuclei with Australia Milliarcsecond Interferometry), is observing a sample of quasars at 8 GHz and 24 GHz bands (see § 5).

### 3. Staff

The staff of the Analysis Center is drawn from individuals who work at the USNO. The staff are: Alan L. Fey, David A. Boboltz, Roopesh Ojha, Ralph A. Gaume, and Kerry A. Kingham.

### 4. Future Activities

The Analysis Center currently has a program of active research investigating the effects of intrinsic source structure on astrometric position determination. Results of this program are published in the scientific literature.

The following activities for 2011 are planned:

- Continue imaging and analysis of VLBA 2.3/8.4/24/43 GHz experiments
- Make additional astrometric and imaging observations in the Southern Hemisphere in collaboration with ATNF partners and the TANAMI program team.

### 5. Relevant Publications

Publications of relevance to Analysis Center activities:

- “TANAMI: tracking active galactic nuclei with austral milliarcsecond interferometry. I. First-epoch 8.4 GHz images,” Ojha, R., Kadler, M., Böck, M., Booth, R., Dutka, M. S., Edwards, P. G., Fey, A. L., Fuhrmann, L., Gaume, R. A., Hase, H., Horiuchi, S., Jauncey, D. L., Johnston, K. J., Katz, U., Lister, M., Lovell, J. E. J., Müller, C., Plötz, C., Quick, J. F. H., Ros, E., Taylor, G. B., Thompson, D. J., Tingay, S. J., Tosti, G., Tzioumis, A. K., Wilms, J. & Zensus, J. A. 2010, *A&A*, 519, 45
- “The Celestial Reference Frame at 24 and 43 GHz. I. Astrometry,” Lanyi, G. E., Boboltz, D. A., Charlot, P., Fey, A. L., Fomalont, E. B., Geldzahler, B. J., Gordon, D., Jacobs, C. S., Ma, C., Naudet, C. J., Romney, J. D., Sovers, O. J. & Zhang, L. D. 2010, *AJ*, 139, 1695
- “The Celestial Reference Frame at 24 and 43 GHz. II. Imaging,” Charlot, P., Boboltz, D. A., Fey, A. L., Fomalont, E. B., Geldzahler, B. J., Gordon, D., Jacobs, C. S., Lanyi, G. E., Ma, C., Naudet, C. J., Romney, J. D., Sovers, O. J. & Zhang, L. D. 2010, *AJ*, 139, 1713